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# SEAM Highlights

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SURFACE ENVIRONMENT & MINING

SEAM

U S D A FOREST SERVICE PROGRAM

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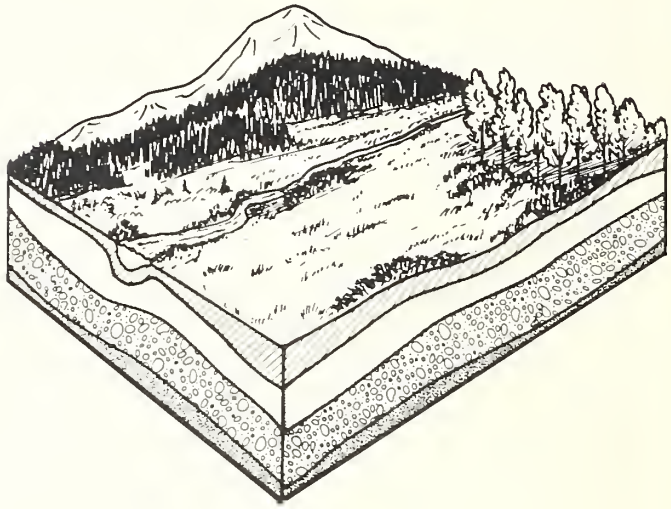
## SEAM PROGRAM: FORGING A LINK BETWEEN THE SURFACE ENVIRONMENT AND MINING



When the Surface Environment and Mining (SEAM) Program was chartered by the Forest Service, U.S. Department of Agriculture, in 1973, its mandate was clear—to provide and apply technology to help manage National Forests and Grasslands affected by rapidly increasing mining activities. SEAM was given 5 years to carry out a Research, Development, and Application (RD&A) program focusing on minerals activities on western forest lands. As an RD&A program, it aimed at a practical goal—to provide needed information related to the biophysical, socioeconomic, and engineering aspects of mining.

This report highlights the contributions of the SEAM Program and describes how it functioned. It relates the types of RD&A projects undertaken, and what is ahead for the programs and concepts generated. Of course, the true effectiveness of the SEAM Program will not be known for some years. Application of new information is not spontaneous; it occurs over time. Fortunately, application of SEAM's research and development efforts will be a continuing part of Forest Service programs.

Steep, unstable mine dumps can contribute sediment and toxic material to stream channels.

## The Need for SEAM

The specter of energy and mineral shortages created a boom in mining activities—a boom that threatened to rapidly outpace our ability to restore the disturbed lands and cope with the social and economic changes that accompany new developments. In the West, where limited research had been done, a special need existed to find ways of mining that would provide reasonable protection of the physical, biological, and social resources.

Forest Service concern in mine land reclamation stemmed from its management responsibilities for 187 million acres of National Forests and Grasslands, which included the mined areas. The Forest Service already had a history of research in the reclamation of disturbed lands. However, the need existed not only to apply knowledge to current problems, but also to direct research skills to new problems.

Land managers who faced increasingly complex and controversial decisions regarding mineral development needed new research information. During the early 1970's some segments of the mining industry and some government agencies recognized the need for better research information and started to develop it. Reclamation research efforts were generally not coordinated, however, and adequate planning was often lacking. Thus, in 1973 with Congressional direction, the Forest Service established the Surface Environment and Mining (SEAM) Program in Billings, Mont. SEAM coordinated efforts and provided assistance to every area of mining activity—from land management planning to exploration, development, and reclamation.

### Taking an RD&A Approach

The real value of an RD&A program depends on its ability to accomplish a specific mission within a limited amount of time. SEAM was established by the Forest Service to provide a rapid response to a particular problem. It thus followed a pattern typical of other RD&A programs, which usually have a relatively short time for generating information and technology to solve a problem. The solutions, in turn, are given to the responsible industry or agency, after which the RD&A program terminates. Such an arrangement allows the RD&A staff to focus on high-payoff projects its audience could not otherwise address. It provides the budget, time, and staff to keep abreast of changes and to identify problems.

The program staff was headquartered in Billings, Mont. Most research was conducted through Forest Service scientists assigned to the Intermountain, Rocky Mountain, and Pacific Southwest Forest and Range Experiment Stations. Other projects were undertaken through contract and cooperative agreements with Federal and State agencies, universities, mining companies, and private consultants.

The primary audiences for the research information generated were Forest Service land managers and specialists, other Federal and State agencies, the mining industry, and universities. These groups participated at various stages in planning the SEAM Program to make sure their needs were addressed.

Today, demonstration sites throughout the West display technology generated by the SEAM Program.

## RESEARCH: SEEKING ANSWERS TO MINERALS MANAGEMENT QUESTIONS

Research information forms the technical foundation of any RD&A program. Although much new technology needed to be developed for the Western United States, considerable technology was already available in the East and some in the West upon which to build. Initially, the SEAM staff reviewed the available information, outlined new research goals, and developed an agenda for periodic meetings with agencies and industries for keeping each other informed.

In addition to the research conducted by the Forest Service Research Stations, 21 universities in 11 Western States conducted studies through contracts or cooperative agreements. Over 35 mining companies cooperated in field studies and demonstrations. Other Federal and State agencies involved in minerals management or reclamation research cooperated on several projects.

Because of its importance to the western mining industry in the early 1970's, coal initially received most of SEAM's attention. Other major mineral commodities, such as phosphate, copper, gold, and silver, were also covered, spanning a range of climates from the plains land in the north to the arid lands in the Southwest to the alpine areas.

### Advancing the State-of-the-Art

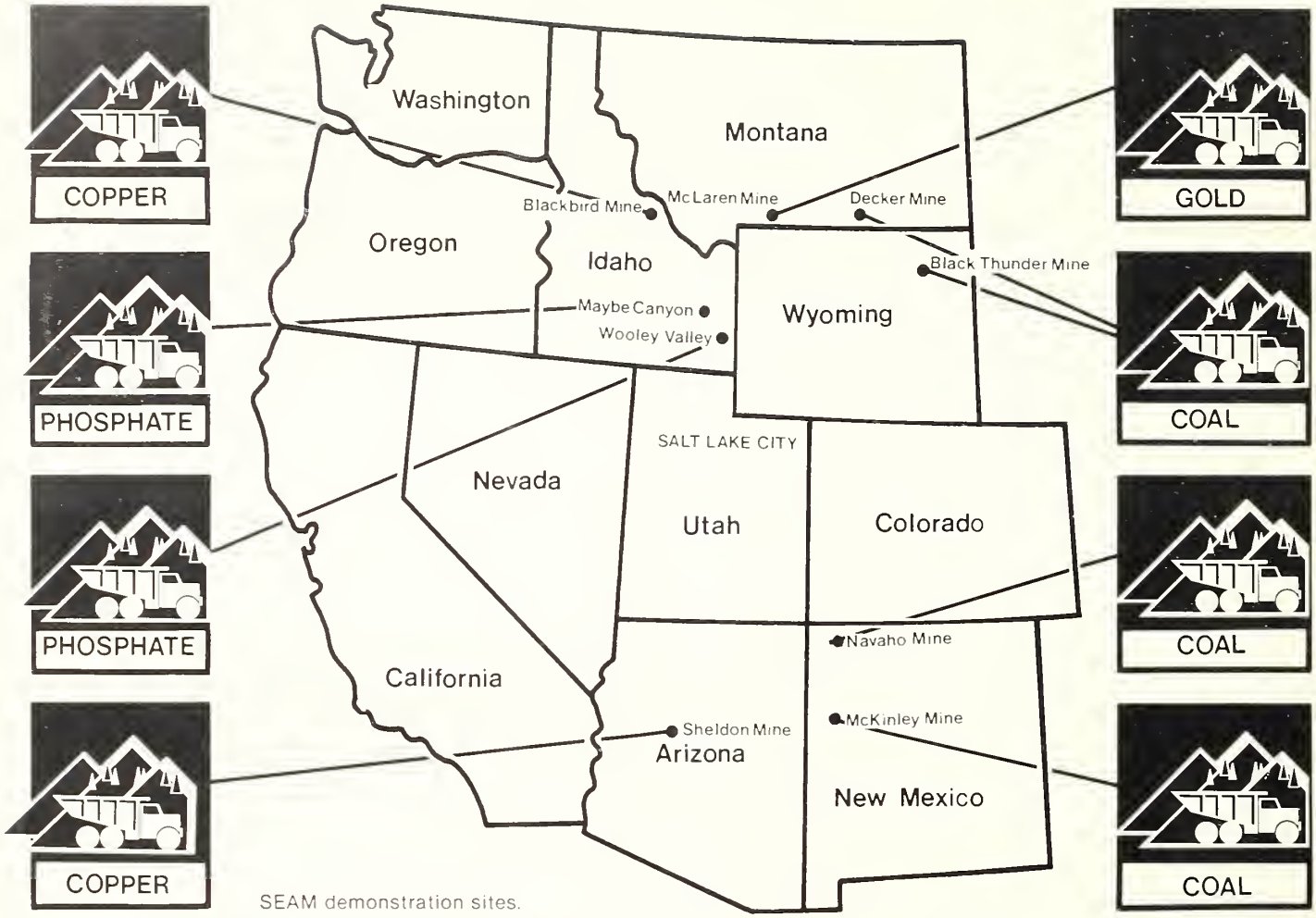
More than 160 SEAM studies represent many aspects of mineral management. Studies of the effects of mining on surface resources included soils, plants, wildlife, air, esthetics, and surface and subsurface water. Field and laboratory evaluations on soils, overburden, and hydrology of areas before mining begins received particular attention. Assessments of air pollution from power plants showed the effects of pollutants on plants and animals and determined how forest ecosystems clean the air by absorbing pollutants. Fugitive dust from mining operations was also measured.

Methods were developed to mitigate adverse impacts for all phases of mining operations: exploration, transportation, development, reclamation, and postmining activities. Special emphasis was placed on such reclamation technology as methods for stabilizing spoil dumps and controlling erosion. Revegetation research included species selection, seeding and planting methods, fertilization, mulching, and supplementary irrigation. In some cases, spoils were unsuitable for growing plants, so soil amendment and topsoiling treatments were developed. Studies on the microbiology of spoils resulted in development of effective tests of spoil fertility.

Another primary concern was reclaiming mined lands to supply the cover and habitat needs of wildlife. Scientists from the Rocky Mountain Station in Rapid City, S. Dak., contributed in developing prescriptions for the needed cover and habitat for certain species of wildlife. SEAM and the Idaho Fish and Game Department worked cooperatively to study the effects of phosphate mining on wildlife.

Today, land managers in the Western States use SEAM information to predict mining effects, to collect baseline data, to classify areas according to their reclamation potential, to prepare post-mining management and monitoring activities, and to set stipulations for transportation systems, grading, revegetation, erosion control, impoundments, and hydrology.

Researchers monitor production and changes in vegetation regularly and pass their recommendations on to industry and land managers for field application. At the Decker Mine in Montana, methods have been developed for reclaiming coal lands on the Great Plains.




SEAM demonstration sites.

### Mine Sites Demonstrate Research Results

Forest Service scientists set up nine demonstration areas on active and abandoned mines in the West. These demonstration sites provided practical problems for researchers as well as a showcase for results and application. Reclamation techniques were developed for the alpine, montane, prairie, and desert geographic regions.

*Alpine*—The harsh alpine climate presents a formidable barrier to reclamation. New techniques were needed because of recent increased interest in mining the platinum, gold, silver, and other heavy metals found in alpine areas. SEAM scientists developed methods to stabilize and revegetate most abandoned mine and exploration disturbances at high altitudes. Acid drainage is much harder to cope with, and only now are scientists beginning to solve this problem.

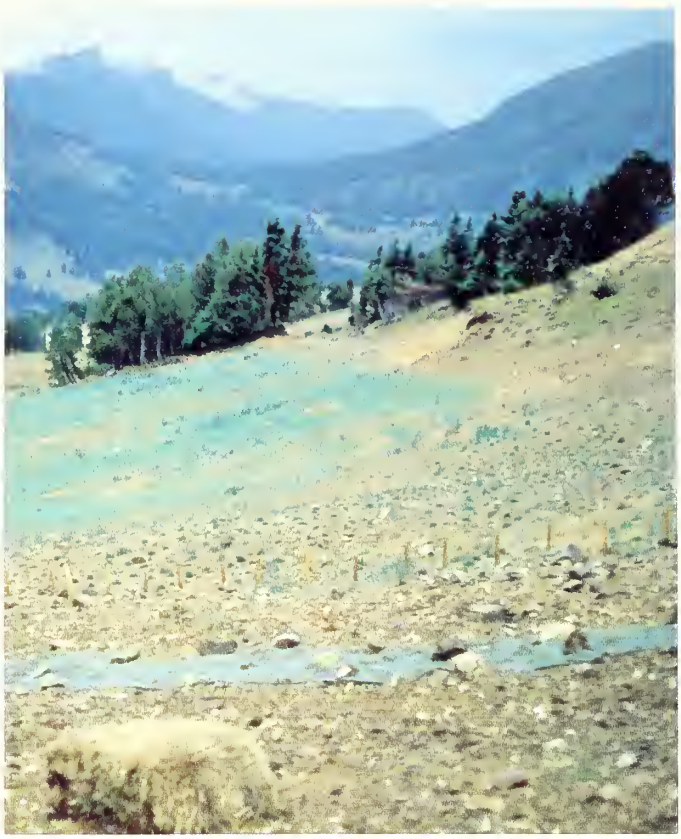
*Montane*—Mining of copper and other heavy metals in the montane areas creates acid spoils and tailings ponds. Water flowing from these areas can carry concentrations of sediment and metal salts into valuable recreation streams and lakes. Revegetation techniques have been developed using soil amendments and mulches to reduce production of acid water. A guide for reclaiming abandoned tailings ponds has been prepared as a result of this research.

Phosphate development in Idaho also presented challenges. Most of the phosphate mining occurs in areas that are also valuable for fish and wildlife. Mine dumps on steep slopes tend to slump and slide, so methods of building and sloping stable dumps were developed. Revegetation of phosphate spoils has been very successful. As a result, erosion on steep slopes has been reduced, and less sediment enters trout streams.

Mines in harsh alpine conditions often contribute acid and toxic heavy-metal runoff into streams and rivers, presenting researchers with reclamation problems. This is seen on an abandoned Montana gold mine (A), where workers in autumn 1976 shaped and contoured a SEAM demonstration area (B). Two years later, seed-producing plants blanketed the once-scarred hillside (C).

A

B



C

Researchers only recently developed methods for successfully revegetating hot, steep, south-facing mine dumps in southeastern Idaho. Vegetation on this slope took about a year to blend in with that of the surrounding mountains.

*Prairie*—Coal mining in the Northern Great Plains is expanding rapidly, leaving mine spoils with high sodium content and heavy textured clay materials. Research has provided successful revegetation techniques on these materials. Scientists have also developed guidelines for building ponds useful for waterfowl and wildlife.

*Desert*—SEAM scientists addressed special revegetation problems for mine spoils in the arid Southwest. Techniques of water harvesting and supplemental irrigation have proved successful in establishing adequate vegetation in these dry areas. Special strains of plants are also being developed that are more adaptable to arid sites.

SEAM scientists have provided basic knowledge for making intelligent reclamation decisions. The ultimate test is the application of research by mining companies whose responsibility is to reclaim lands disturbed by past or current mining. Many companies throughout the West are indeed using the techniques developed by SEAM research.

Stripping the overburden exposes coal in the Decker Mine in Montana. Topsoil is stockpiled for redepositing on spoils.

Researchers' sample plots help provide industry with successful prescriptions for surface mine revegetation.

After the first growing season, small wheatgrass plants germinate in the rough surface material found in arid lands. After several growing seasons, the plants are dense and vigorous.

## DEVELOPMENT: REFINING TOOLS FOR MINERALS MANAGEMENT

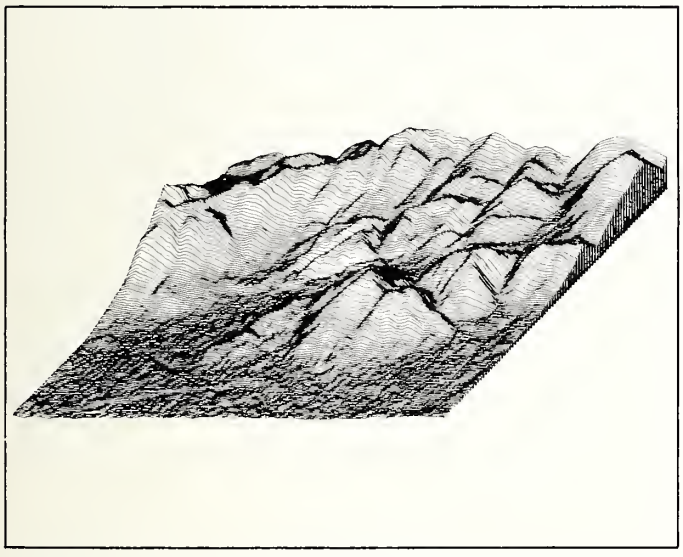
Development involves molding existing knowledge and technology into a form that can be used on specific projects. In SEAM's case, development programs focused on reclamation, plant materials, computer tools, social science methods, and decisionmaking processes—and how all these could be applied to mining.

### Developing Plant Materials for Reclamation

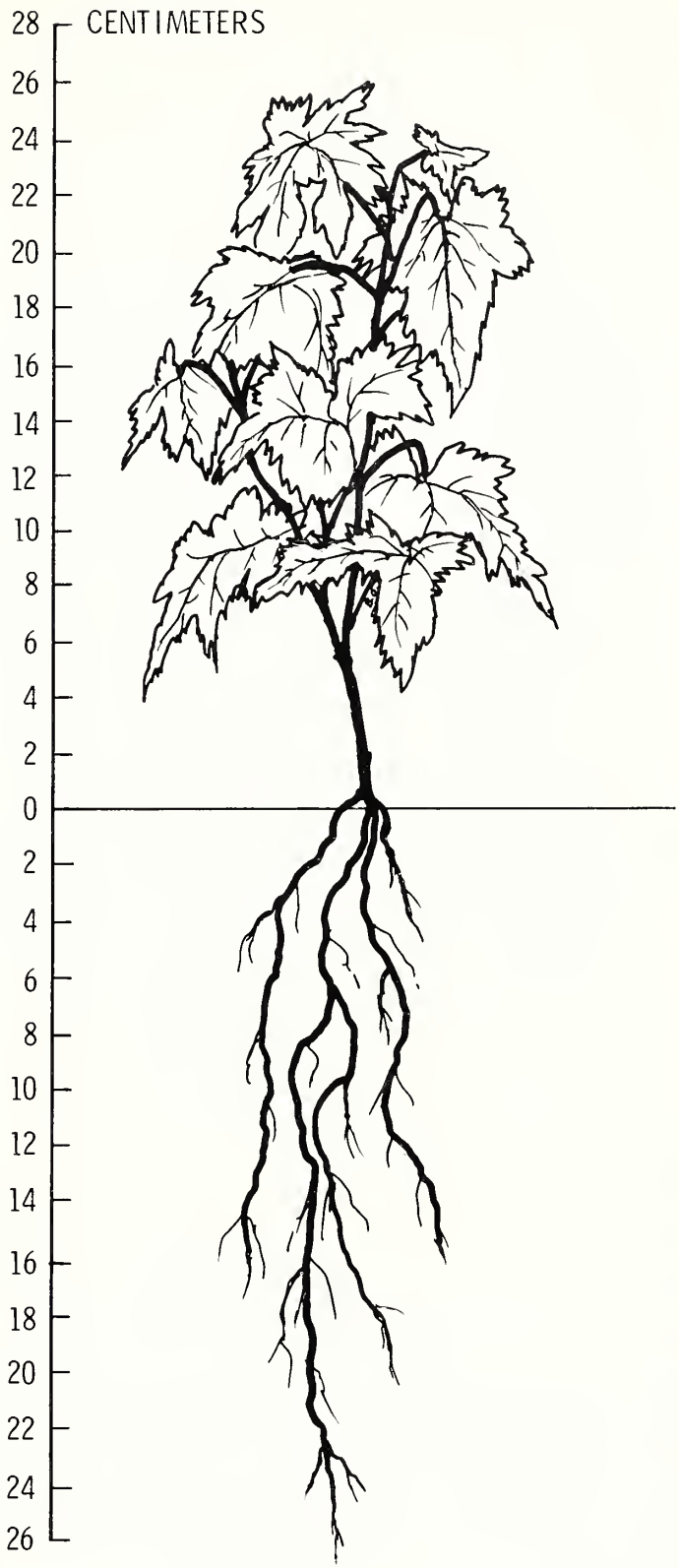
SEAM funds accelerated the search for plant materials that would adapt to revegetation work on mined lands. Such an effort is essential so that plant species will survive on the varied, and often rugged, sites and climatic conditions encountered at western mine sites.

A project at the Forest Service Nursery in Coeur d'Alene, Idaho, provided critically needed shrubs for reclamation sites. The greenhouse conditions resulted in plants with strong root systems —an essential characteristic for survival on harsh sites. The containerized shrubs were planted on reclamation sites throughout the West.

The availability of grasses adaptive to reclamation was speeded by a cooperative venture between SEAM and the Soil Conservation Service (SCS). SCS Plant Material Centers in Los Lunas, N. Mex.; Bridger, Mont.; Bismarck, N. Dak.; and Meeker, Colo., participated with SEAM in producing these grasses that not only help stabilize the soil but also provide cover and habitat for wildlife.



Computer-drawn, 3-D graphics display the location and size of ore bodies and help researchers and industry select cost-effective mining operations.




Shrubs produced in greenhouses develop strong, straight, and deep root systems necessary for survival on harsh sites. Research shows such shrubs help prevent runoff on reclaimed land.

### Putting the Concerns of People into Forest Planning

Social and economic changes caused by mining on land that is on or adjacent to a National Forest often have a direct effect on Forest Service resource decisions. To help land managers predict social and economic changes more effectively, guidelines were developed for social impact assessments and social resource management. The guidelines help the Forest Service meet its dual needs of predicting social changes that result from mineral, recreational, and other resource developments on or near Forests or Grasslands, and of allocating forest resources so that social benefits are enhanced and social disruption minimized. The result was a 10-step procedure that sociologists and nonsociologists alike might use. The guidelines are now being tested on National Forests throughout the country.

### QRD—A Systematic Approach to Decisionmaking

A contract with Utah State University resulted in the development of the Questions, Rules, Data (QRD) concept. QRD provides a framework for a logical decisionmaking process and a systematic approach to data gathering. QRD assists the land manager in identifying specific questions, developing rules that apply to the questions, and determining what data are needed. The concept is supported by an ecological classification system called ECOSYM, a computer-assisted process.

### Computer Tools Aid Land Managers

SEAM initiated several computer-based systems designed to help collect, process, and display mineral-related information. Development on these systems continues with the intent of putting them into use. The systems include:

LANDFORM—This system combines existing and developmental computer programs to gather surface and subsurface data in digital form, to use it in such calculations as ore quality and overburden volumes, and to produce visual plots useful for both land management planning and engineering design.

MOSAIC—This system produces low-cost, computer-drawn designs of proposed resource developments, such as surface mines, transmission corridors, pipelines, and roads.

SEAMPLAN—This minicomputer-based system helps plan and design surface coal mining operations involving single-seam, dragline mining techniques. It also monitors operations once production is under way.

MICRO-D—This computer-based tool rapidly digitizes map source information.

## APPLICATION: TECHNOLOGY TRANSFER

### The Process

Considerably more is known about generating information than about transferring it to users and getting it applied. Consequently, a great disparity exists between the amount of information available and the amount used.

To solve this problem, SEAM developed a user-oriented technology transfer process consisting of the following phases:

1. *Need identification.* Initially, the problem statement and study plan are prepared.
2. *Information development.* The project is implemented and data are collected.
3. *Packaging.* Project results are documented, using many communication skills.
4. *Transfer.* Information is disseminated to user audiences.
5. *Application.* Users are provided assistance in implementing new knowledge, monitoring its progress, and documenting any refinements.

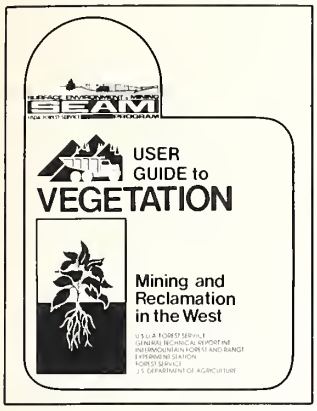
To implement this process, SEAM established technology transfer specialist positions in four Forest Service Regional Offices in the West. Their basic responsibility was to act as liaisons or links between Forest Service Research and the National Forest System users, as well as other user audiences.

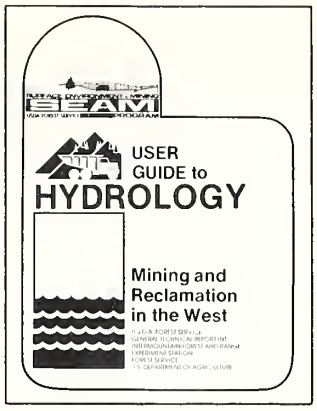
In addition to the technology transfer specialists, SEAM involved other users to ensure that results met their needs and would thus be more readily accepted. SEAM provided staff aid and funds for computer support to several National Forests, including the Uinta and Manti-LaSal in Utah, the Grand Mesa-Uncompahgre-Gunnison and Arapaho-Roosevelt in Colorado, and the Coronado in Arizona. These efforts helped develop prototype techniques for integrating minerals considerations into the land use planning management processes. Today, this knowledge is being documented for transfer to other National Forests.

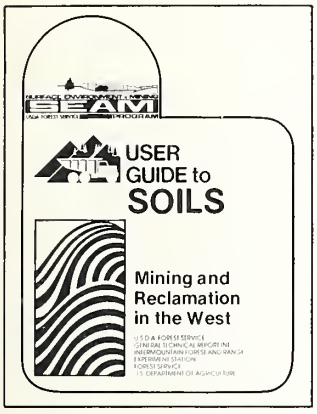
### Packaging the Results

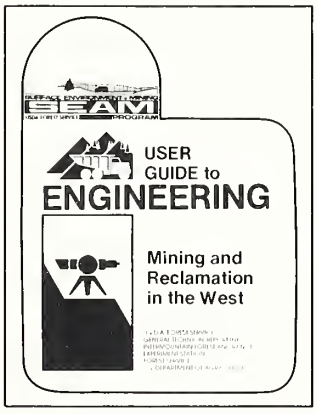
Packaging information to meet the needs of audiences is an important facet of technology transfer. Some SEAM research results are presented in training manuals, while others are in such diverse media as a magazine, a slide show, and a handbook. The majority of SEAM publications are in the form of easy-to-read handbooks and how-to guides. These publications include:

*Handbook for Land Managers.* A hurdle to effective minerals management is the maze of legislation and diffused authority among different governmental organizations. Federal and State




agencies share jurisdictional authorities, legal and regulatory requirements vary, and mineral activities are diverse. Land managers often express a need for a guide outlining roles and authorities of the participants throughout the minerals development process, from prospecting through reclamation.

In response, SEAM developed a Handbook for Land Managers that describes the administrative and scientific responsibilities and processes of the Forest Service related to minerals activity on or adjacent to National Forests and Grasslands. Originally developed to encompass minerals development in the West, the handbook was expanded for nationwide application.

*User Guides on Vegetation, Soils, Hydrology, Engineering, and Sociology and Economics.* One of SEAM's major challenges was translating results of work into a format that would be used by the specialists working with minerals activity on location.

Because intuitive knowledge often develops when scientists and users get together, SEAM created its User Guides using a workshop approach that encouraged interaction between scientists and users. Participants in five workshops helped generate a series of user guides on vegetation, soils, hydrology, engineering, and sociology and economics. These guides cover various stages of minerals management—from land use planning and prospecting through reclaiming and post-mining monitoring—and list the effects these activities have on surface resources.

*Minerals Planning Handbook.* This handbook, also developed using the workshop approach, helps specialists integrate minerals concerns into the land planning process.

*The Joint Review Process.* This report gives a detailed description of reviewing and planning a major mineral development. As an example, it outlines the process used in a mining proposal at Crested Butte, Colo. The report includes a sample agreement that defines procedures for various agencies, companies, and individuals involved in reviewing the applications for such a development.

*A Guide to Reclaiming Small Mine Dumps and Tailings Ponds.* This report grew out of a cooperative effort among SEAM, the Prescott National Forest in Arizona, and the Arizona Department of Renewable Resources at the University of Arizona. The tailings pond and mine dump were near Prescott, Ariz.

*Anatomy of a Mine from Prospect to Production.* This report summarizes Federal legislation affecting mining, defines terms used in the mining industry, and discusses basic concepts of mineral exploration, development, and operations in the West. Although primarily intended for Forest Service land managers, the report has gained widespread popularity with land managers and planners in other agencies, and with environmentalists and mining industry personnel.

*Creating Land for Tomorrow.* A national workshop on this subject was sponsored by SEAM and the American Society of Landscape Architects. The thrust of the workshop—and of the resulting document—was to involve landscape architects in planning for the landforms that result from mining, and to increase the mining industry's interest in the landscape architect as a contributor to planning. The report was published as part of the Landscape Architecture Technical Information Series.

The effective transfer of information covers many skills and techniques. In addition to the technology transfer specialists, Forest Service scientists play a key role in information transfer by participating in training sessions, workshops, symposia, and university short courses. Computer-based information systems such as WESTFORNET and SEAMALERT provide access to major sources of publications dealing with minerals management. Demonstration areas serve industry and agencies alike through application of practical on-site reclamation practices. Interagency and specific-user-group meetings also serve as forums for information exchange.

## FOLLOWUP AND CONTINUING WORK

When the SEAM RD&A Program in Billings came to the end of its allotted 5 years it was necessary to continue selected projects. Projects needing further research or written reports were assigned to various Forest Service operating units. Successful demonstration areas will need maintenance and monitoring over an indefinite period to ensure continued usefulness. SEAM-developed tools are being used and tested on planning efforts on several National Forests.

Effective technology transfer means more than printing and distributing publications. Thus, in order to carry forward the process—to make sure SEAM information is used in the field—the Forest Service's Minerals and Geology Staff in Washington, D.C., arranged for a 2-year followup training program. A staff at the Regional Office in Ogden, Utah, will package, plan, and conduct training programs, and provide leadership and direction to the knowledge transfer effort. For example, SEAM Program knowledge could possibly be incorporated into reclamation courses taught at western universities. "Home units"—for instance, Forest Service Regional Offices—will be encouraged to maintain the currency of information and to make sure it is disseminated.

If available knowledge is properly applied, few doubt that most mined land could be restored to a valuable use—sometimes, in fact, made even more productive than before it was mined. Such an effort will require the cooperation of government, industry, and the public—but it is a task that can be done.

Significant progress has been made in reclamation research in the West, but much remains to be done. The steadily growing mining activities involve a myriad of minerals and a wide variety of climatic, soil, hydrologic, and topographic conditions. SEAM, in cooperation with research scientists and members of the user community, identified a wide range of mineral-related needs for future research to focus on:

- Reclamation of alpine areas and arid lands
- Reclamation of abandoned mined lands
- Reclamation of tailings ponds
- Impacts of geothermal, oil shale, and uranium development
- Impacts of oil and gas exploration and development
- Modeling of impacts and trade-offs
- Surface stability of mined lands
- Surface and subsurface water hydrology
- Plant and animal interactions
- Manipulation of mine spoils to form productive soils

Emphasis is also needed on socioeconomics, landscape architecture, and engineering.

## FOR MORE ON SEAM

Those interested in obtaining SEAM-sponsored publications and computer programs should request "Bibliography of SEAM Publications," USDA Forest Service General Technical Report INT-78, from the Intermountain Forest and Range Experiment Station, Ogden, Utah.

Specific titles may be requested from SEAMALERT, a computerized monthly publication produced through a cooperative agreement between the University of Arizona and the Office of Surface Mining, U.S. Department of the Interior. All SEAM-related publications, as well as publications, reports, and articles gathered from scientific and popular journals of surface environment and mining, have been compiled and indexed in SEAMALERT. Retrievals may be made either onsite through terminal access to the computer, or offline through telephone or letter requests.

To borrow materials announced in SEAMALERT, contact State, Federal, or other libraries that regularly provide professional literature. To be placed on the SEAMALERT mailing list, write the Office of Arid Lands Studies, University of Arizona, 845 North Park Avenue, Tucson, AZ 85719.

Forest Service personnel may request SEAM materials through WESTFORNET, a Forest Service in-house information system. Requests should be addressed to: WESTFORNET—Ogden, Intermountain Forest and Range Experiment Station, 507 25th Street, Ogden, UT 84401.

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RESEARCH
APPLICATION
DEVELOPMENT